PRAM PROGRAM
FINAL REPORT

Robotic Paint Booth
WR-ALC/LFPLE

F-15 System Program Office
Warner Robins Air Logistics Center
Robins Air Force Base, Georgia

20 July 1994

Approved by:

STEPHEN L. DAVIS
Executive Director

TAB Number:	5068
PRAM Number:	02689-01
Project Officer:	Gerald Peavy
Office Symbol:	WR-ALC/LFPLE
Telephone No:	DSN 468-4340
	912 926-4340

TABLE OF CONTENTS

1. EXECUTIVE SUMMARY

F-15 aircraft scheduled for Programmed Depot Maintenance (PDM) normally have 10-15 coats of paint. The aircraft must be completely stripped, inspected for corrosion, and then repainted. Air Force PDM is designed to identify and repair aircraft structural or mechanical problems before they become critical.

The FY89 PDM package for F-15s required a minimum of 100 aircraft per year and a potential workload of 850 aircraft over the next five years (maximum 170 per year) to be accomplished at Warner Robins. This task was only supportable with additional man-hours, equipment, and facilities, or a more efficient, less manpower-intensive method for PDM.

Warner Robins firmly believed that an automated preparation and paint system could be developed which would meet all the Air Force quality and safety requirements and eliminate the F-15 support problem.

In designing the system, it was discovered that the size of existing robots was not sufficient to reach all parts of an F-15 aircraft with the robot stationary. The only solution was to move the robot itself in three dimensional space. This solution added complexity because each additional degree of freedom required an additional input and output to be controlled. To spray paint from above, below, and around the aircraft, a platform-on-a-curved-track configuration was selected. To wash, etch, and alodine, a gantry system concept was chosen for fast and complete coverage.

This project was initiated in 1988, cost $4.9M, and was funded with FY89 and FY90 dollars. The system was placed in use for production painting of PDM aircraft at Robins AFB in January 1993. The concept of robotic aircraft surface preparation and painting was demonstrated to be feasible. The prototype system installed at Robins continues to be optimized for production, while being fully production capable.

2. INTRODUCTION

In FY89, the WR-ALC F-15 programmed depot maintenance (PDM) workload was raised to 100 aircraft; the ALC was not prepared to meet this workload and reduced the workload to 78 aircraft. However, there still was a need to increase the capability in order to meet this yearly workload in the future. The ALC needed to either increase the manpower and facilities (which was not an option), or develop more efficient methods to PDM the aircraft. The best way to improve efficiency is to eliminate the bottlenecks. One of the main bottlenecks in the PDM operation was the preparation and painting of the aircraft. Manual painting of aircraft consumes an inordinate amount of resources, labor, materials, and flow time, as well as being hazardous to personnel. If the time to prepare and paint an aircraft could be reduced by automating the process, the flow time would be reduced, personnel would be removed from a hazardous environment, and those people no longer needed would be available to reduce bottlenecks in other areas. With this in mind, the F-15 robotic paint booth project was born. PRAM funded the project in FY89 and FY90 for a total cost of $4.9M.

The completed booth is now referred to as the Small Aircraft Finish Application Robotic Installation (SAFARI). This project consists of a booth specifically designed to support the robotic equipment and F-15 paint processes, using climate controls or HVAC systems, air filtration system (thermal fume oxidizer), chemical mixing and dispensing, and the robotics. This system is designed to wash, etch, conversion coat, prime, paint, and camouflage the F-15. Additional capabilities will be developed in the future, each of which will reduce flow time and production cost.

3. TECHNICAL INVESTIGATION

Statement of the Problem

Manual painting methods require that personnel work in a hazardous and uncomfortable environment. Painting requires that these conditions exist for a full shift and more. No worker can maintain precise control of the paint gun for an extended period of time. To obtain full coverage, it is necessary to apply excess paint, resulting in waste and runs, which necessitate rework and still more waste.

Investigation and Findings

Robotic painting is a mature technology. Reach of existing robots is not sufficient to reach all parts of an F-15 aircraft.

Technical Approach

Integration of "external axes" to a standard robot and controller was the approach chosen. This means that the robot itself is moved in three dimensions, each of which is an additional degree of freedom and requires an additional input and output to be controlled.

A gantry was chosen for wash, etch, and conversion coating operations. To spray paint from both above and below the aircraft, a platform-on-curved-track configuration was selected. The platform holds the robot and is able to extend far enough to reach the center line of the aircraft.

Conclusion and Recommendations

The concept proved feasible. The hardware and software developed under this project are in production; however, we believe with current advances, system upgrades will make it easier to use.

4. LESSONS LEARNED

a. Always buy reprocurement documentation in developmental contracts. This contractor has proprietary rights which limit troubleshooting and modification procedures.

b. When requirements change, close out all tasks in an orderly and definite manner. In this project, the type paint to be used changed during the programming task. The programming task was closed out, accepting the contractor's claim that the program was nearly complete, and a new task was initiated to reprogram for high-solids paint. The time and cost required to complete this new task raised doubts as to the contractor's claim on the original task; however, the Government had no recourse at that time.

c. Failures have occurred due to inadequate preventive maintenance.

d. Flexible shifts and manpower are required to support robotic operations.

e. Parts and material support is the single most important task to keep a robotic system operational, since a small and inexpensive part may prevent the using organization from painting with an automated system if it is not readily available.

5. IMPLEMENTATION

Approach

The developmental hardware and software have been used for production since January 1993. We continue to be in a production build-up status. This status could be improved by better parts support; as time passes, we experience less problems in this area.

Status:

Complete

Validation of Savings:

We are still in a production build-up phase and have not reached full capability.

Schedule:

Implemented in January 1993. Expect full capability by October 1994.

6. ECONOMIC SUMMARY

Expenditures

FY89	$2.3M
FY90	$2.6M

Savings in man-hours:

Labor Grade	Previous	Current	Saving
WG-07	30	20	10
WG-09	15	10	5

Production began in January 1993, savings are computed from that date at the rate of: (10 x 2087 x $11.90)+(5 x 2087 x $12.76)= $381503 for the year. Wage Grade employees received no raise in 1994, so labor savings are the same. Savings after 1994 are escalated at 1.6 percent per year.

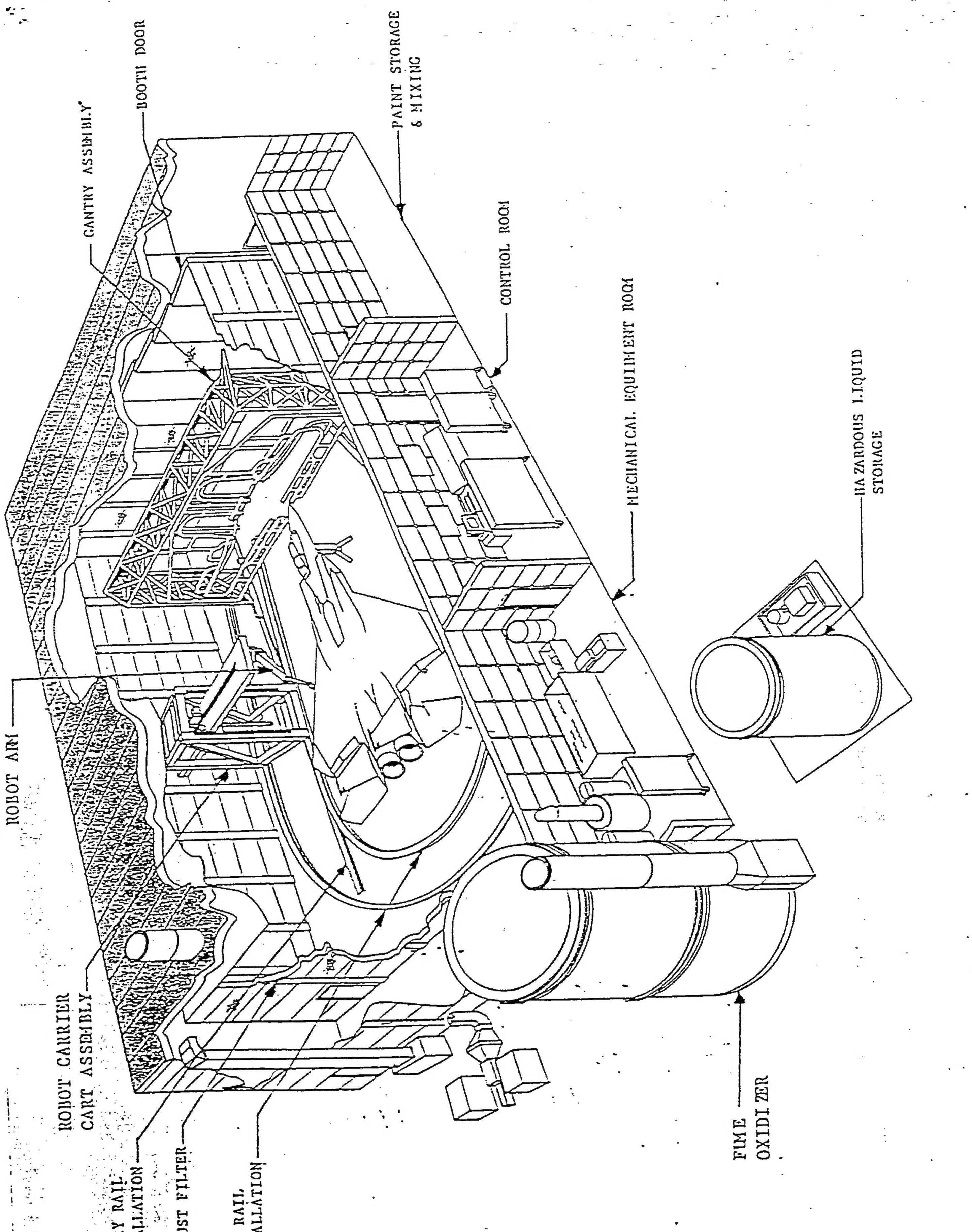
Material savings are estimated at $2500 per aircraft. This is applied to 71 aircraft in 1993, 60 in 1994, 78 in 1995, and estimated at 80 each year thereafter.

Annual savings are therefor $381503.00+$177500.00=$559003.00 for 1993, $381503.00+$150000.00=$531503 for 1994, $387607.05+$195000.00=$582607.05 for 1995, etc. Cumulative savings will be $6 million after 10 years.

Payback is calculated to be 10 years, beginning January 1993 and completed by January 2003.

APPROVAL AND COORDINATION
Robotic Paint Booth

OFFICE SYMBOL	SIGNATURE	DATE
LFPLE	[illegible]	5 Aug 94
LFPL	Joel T. Murphy	5 AUG 94
LFP	[illegible]	9 Aug 94
LF	[illegible]	10 Aug 94
SES	[illegible]	10 Aug 94
PRAM Mgr.	[illegible]	3 AUG 94
TIET	[illegible]	17 Aug 94
TIE	[illegible]	25 Aug 94
TI	[illegible]	13 Sep 94


BOOTH DOOR
GANTRY ASSEMBLY
PAINT STORAGE & MIXING
CONTROL ROOM
MECHANICAL EQUIPMENT ROOM
HAZARDOUS LIQUID STORAGE
ROBOT ARM
ROBOT CARRIER CART ASSEMBLY
GANTRY RAIL INSTALLATION
EXHAUST FILTER
CART RAIL INSTALLATION
FUME OXIDIZER

PRAM PROGRAM OFFICE
FINAL REPORT DISTRIBUTION LIST

AEDC/XR
100 KINDLE DR, SUITE A214
ARNOLD AFB TN 37389-1214

SA-ALC/CN
485 QUENTIN ROOSEVELT, SUITE 4
KELLY AFB TX 78241-6425

NAVAL AVIONICS CENTER
ATTN: MR GARCIA
BRANCH 453, 6000 E 21ST ST
INDIANAPOLIS IN 46219-2189

RL/RAC
ATTN: WILLIAM H. CROWELL
201 MILL ST
ROME NY 13440

WR-ALC/TIET
255 SECOND ST, SUITE 122
ROBINS AFB GA 31098-1637

ACC/DRL
204 DODD BLVD, SUITE 226
LANGLEY AFB VA 23665-2777

SECRETARY OF THE NAVY
CPS, RM348
2211 JEFFERSON DAVIS HIGHWAY
ARLINGTON VA 22202

HQ AFRES/LGMMB
155 2ND ST
ROBINS AFB GA 31098-6001

OC-ALC/TIETP
BLDG 3001, POST 2AF 66A
TINKER AFB OK 73145-5990

GENTILE STATION
ATTN: JDMAG/MAT
108 HAMILTON ST
GENTILE AFS OH 45444-5370

SM-ALC/CN-1
ATTN: MR "TAG" TAGUBA
3237 PEACEKEEPER WY, SUITE 13
MCCLELLAN AFB CA 95652-1058

HQ AMC/XRATE
402 SCOTT DR, RM 132
SCOTT AFB IL 62225-5363

OO-ALC/TIETE
5751 F AVENUE
HILL AFB UT 84056-5713

ASC/SMT (3 COPIES)
BLDG 22, 2690 C ST, SUITE 5
WRIGHT-PATTERSON AFB OH 45433-7412